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Lubrication

*A Technical Publication Devoted to
the Selection and Use of Lubricants*

THIS ISSUE

The Sugar Industry—
Machinery Operations
and Lubrication



PUBLISHED BY
THE TEXAS COMPANY
TEXACO PETROLEUM PRODUCTS

TEXACO LUBRICANTS FOR SUGAR MILL MACHINERY

A Suggestive List

Showing a number of places in which the Texaco Lubricants designated have met with marked success.

TRANSPORTATION EQUIPMENT

TRACTORS AND MOTOR VEHICLES

Internal Combustion Engine	{ TEXACO MOTOR OILS
Cylinders and Bearings	{ (According to Manufacturer's Recommendations)
Transmission and Differential Gears	{ TEXACO THUBAN COMPOUNDS
	{ (According to Operating Temperatures)
Chassis and Other External Parts	{ TEXACO CUP GREASES, OR
	{ TEXACO MARFAK GREASES
Steam Type Tractors	
(Cylinders)	{ TEXACO PINNACLE CYLINDER OIL, OR
	{ TEXACO LYRA CYLINDER OIL
External Lubrication (<i>Oil Lubricated</i>)	{ TEXACO 671 OIL
(<i>Grease Lubricated</i>)	{ TEXACO CUP GREASES
Gears	{ TEXACO CRATER COMPOUND NO. 1

RAILWAY EQUIPMENT

Steam Cylinders	{ TEXACO PINNACLE CYLINDER OIL, OR
	{ TEXACO 631 CYLINDER OIL
External Bearings (<i>Oil Lubricated</i>)	{ TEXACO LOCOMOTIVE ENGINE OIL
(<i>Grease Lubricated</i>)	{ TEXACO GREASE NO. 923
Driving Journals and Crankpins	{ TEXACO DRIVING JOURNAL COMP. "M"
Car Wheel Journals	{ TEXACO CAR OILS, OR
	{ TEXACO BEARING OIL "S"

CARTS AND WAGONS

Plain Bearings	{ TEXACO VEGA AXLE GREASE, OR
	{ TEXACO 671 OIL

HARVESTING AND CONVEYING MACHINERY

CANE HARVESTERS

Internal Combustion Engines	{ TEXACO MOTOR OILS
	{ (According to Manufacturer's Recommendation)
Reduction Gearing	{ TEXACO THUBAN COMPOUND "S"
External Bearings	{ TEXACO CUP GREASES, OR
	{ TEXACO GREASE NO. 923

ELEVATORS, CONVEYORS AND CANE CARRIERS

Bearings (<i>Drip Lubricated</i>)	{ TEXACO ALTAIR OIL
	{ TEXACO ARIES OIL, OR
	{ TEXACO TEXOL "F"
(<i>Circulating Systems</i>)	{ TEXACO ALCAID OIL, OR
	{ TEXACO TEXOL "D"
(<i>Grease Lubricated</i>)	{ TEXACO CUP GREASES
Steam Cylinders	{ TEXACO PINNACLE CYLINDER OIL, OR
	{ TEXACO LYRA CYLINDER OIL
Chains (<i>Exposed</i>)	{ TEXACO THUBAN COMPOUND "K" OR "S"
(<i>Enclosed</i>)	{ TEXACO THUBAN COMPOUND "H"
Gears (<i>Exposed</i>)	{ TEXACO CRATER COMPOUND NO. 1
(<i>Enclosed</i>)	{ TEXACO THUBAN COMPOUND "S"

(Continued on inside of back cover)

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The Sugar Industry—Machinery Operations and Lubrication

SURROUNDING the production of certain essentials of life there still exists an atmosphere of romance; an atmosphere wherein the memories of an earlier age of engineering still prevail. It is a relief to those who deal with modern engineering to work with such an industry, where acceptance of the developments of our mechanical age has not, as yet, become too casual.

Outstanding in this regard is the sugar industry. Perhaps it has retained its memories of the past by reason of its association with the era of new world conquest, for modern cultivation of the sugar cane and production of cane sugar dates back to the days of the Conquistadors.

Sugar cane is known to have come from the East, many authorities claiming Cochin, China, as its original homeland, whence it was introduced into India, Arabia and throughout the Mohammedan Empire, during the period of political supremacy of the Arabs. Cultivation of sugar cane in Spain may, therefore have originated with the Moors. It is quite reasonable to presume that with knowledge of its economic value the Spaniards introduced it into the West Indies, Mexico, South America, and later into the Philippines, teaching the arts of cultivation, grinding and elementary refinement to the natives in each instance.

The manufacture of sugar from beet roots was a later development, distinctive by reason of its advance in the temperate climates. The garden-variety of beet has been known to man

as a food for centuries, being particularly popular in continental Europe. Cultivation of the sugar beet, however, is a far more recent development; commercially it has been stimulated and improved to enable it successfully to compete with the sugar cane over recent years as a source of the world's sugar supply.

With both types, effort has been made to utilize the products as completely as possible. In the beet sugar industry for example, the residue after diffusion or removal of the juices, is frequently used as cattle food, research has also indicated that it is practicable to subject the residuum molasses to a further extraction process. Supply and demand will indicate whether this will continue to be economically advantageous.

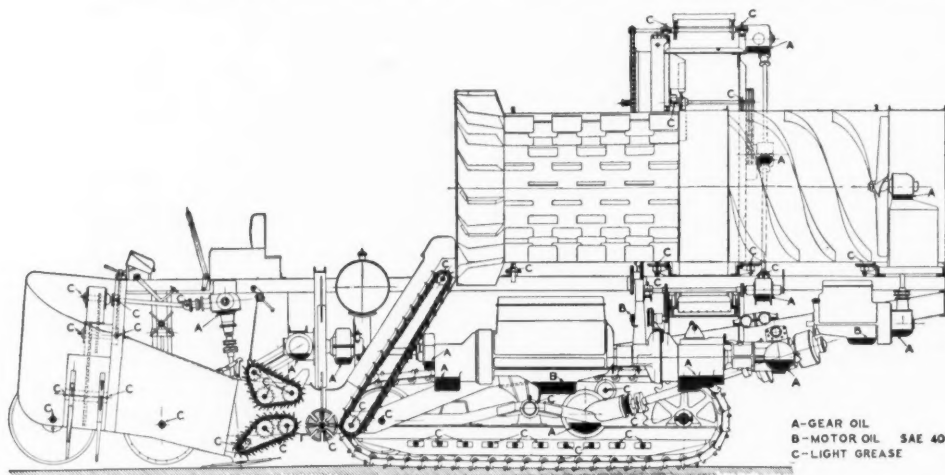
SUGAR CANE CULTIVATION

A sugar cane is composed of root, stalk, leaves and some species have a head of flowers. The stalk, which contains the sugar juice, is ringed with joints at about 2 to 6 inch intervals throughout its entire length, of from 8 to 12 and sometimes 20 feet; each joint contains a bud, which is the germ of a new cane. Luxurious, blade-like leaves spring out at every joint of the stalk, the topmost leaves clustering into a thick bunch. As the cane ripens, out of the sheath aloft shoots an arrow, long and slender and richly adorned with white or grey feathery heads of countless little silken flowers.

Broadly speaking, the system of sugar cane cultivation is the same in all parts of the sugar

world, and every cane crop not only gives a sugar harvest but supplies a stock of cuttings for the next season's planting. After the harvest the ground is plowed or hand-forked, and either furrowed or drilled in rows, from 3 to 6 feet apart; plant canes or cuttings from the tops of

After the canes are cut or the beets pulled, they must be transported to the mills. The general wide area of many sugar estates has justified the use of railway transportation for this purpose. Where no railway system is installed the raw products are taken to the mills



Courtesy of Falkiner Cane Harvester Corp. of America and Allis-Chalmers Manufacturing Company
Fig. 1—Lubrication diagram for the Falkiner cane harvester. A indicates points where gear lubrication is essential; B, internal combustion engine lubrication, and C, points of application for grease.

ripe canes are then laid horizontally in the furrows or holes, or thrust in at an angle, a foot or two apart, and lightly covered with earth. The eyes of the joints soon begin to spring, and the young canes enter on the life of about 16 months, which they require to reach a state of perfection; the roots split up and spread in all directions.

The canes are chiefly reaped by hand with different kinds of knives in different parts of the world; they are severed close to the ground and any leaves remaining are cut off, a short piece is then slashed off from the top to be kept for planting. The stalks are taken to the mills to be crushed, some being hauled by locomotives and trains, some by mule and donkey carts, and some in punts drawn by mules through canals, the latter method being in operation in Dutch and British Guiana where canals transverse all parts of the fields. The leaves of the canes are used for fodder.

CULTIVATION AND TRANSPORTATION MACHINERY

Cultivation of the sugar beet and sugar cane, and transportation to the mill involves machinery which may often present problems of lubrication.

Modern methods of cultivation have tended toward the adoption of the tractor, by virtue of the facility with which ploughing can be done and the fields prepared for the next year's growth.

by means of trucks, animal drawn carts or other vehicles as mentioned heretofore, according to locality.

At the mills the cuttings are conveyed to the grinding machinery by cane elevators. Similar elevators are also installed in the beet sugar factory. In large plants where an extensive volume of product may be involved, mechanical car dumpers may also be installed to facilitate emptying the cane or beets from the railway cars into the conveying elements.

The above machinery involves numerous parts requiring careful lubrication if continuous operation is to be accomplished. This latter is particularly essential, in view of the short season, making it highly advisable for all machinery to function without disruption.

Lubrication Practice

Tractor lubrication is essentially a matter of servicing the particular type of internal combustion engine installed. The same holds true for the driving engines of the cane harvester. In all cases either gasoline or kerosine engines are used, although the use of the Diesel may increase in the future.

Internal combustion engine lubrication should not be a difficult problem, providing lubricating oils are used of viscosity commensurate with engine design and operating temperatures. Normally lubrication charts can be obtained from reputable manufacturers of lubricants, which have been worked out in conjunction

with the manufacturers of internal combustion engines.

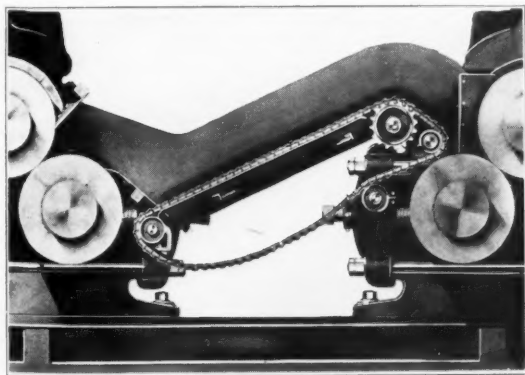
As a general rule an oil of from 700 to 1200 seconds Saybolt viscosity at 100 degrees Fahr., will meet average tractor engine requirements. Particular attention should be given to the carbon residue content of the original oil, by virtue of the fact that in all probability the engines will be overloaded a considerable part of the time, and subjected to temperatures which may cause extensive accumulation of carbon on piston heads, valves and rings, unless the oil is refined with due regard to the possible detriments of carbon. It is possible to obtain high grade lubricants within the above range of viscosity, with a carbon residue content below 0.1 per cent.

In regard to railway equipment lubrication, in view of the fact that steam is the prevailing means of developing power, especially in the tropics, it must be considered from the angle of steam cylinder lubrication, locomotive bearings and car wheel journals.

Steam cylinder lubrication in the sugar industry may involve the stationary or the locomotive type of engine. It can be generally studied from the viewpoint of selecting one oil to serve both types of engine. The same oil can also be used for steam tractor engine lubrication where such machines are employed.

As a general rule, a high grade compounded oil, of a viscosity in the neighborhood of 135 to 145 seconds Saybolt at 210 degrees Fahr., will serve the average requirements of steam cylinder lubrication.

For general engine bearing lubrication, as



Courtesy of Link-Belt Company

Fig. 2—Constructional details of a Link-Belt intermediate bagasse carrier between mills. Presence of moisture and cane juices creates a problem in lubrication.

well as for the lubrication of the majority of smaller bearings or mill machinery, a straight mineral engine or machine oil, ranging in viscosity from 300 to 500 seconds Saybolt at 100 degrees Fahr., will function satisfactorily.

Car wheel bearing lubrication, in turn, will

normally present requirements much similar to those which prevail in general railway service. In view of the fact that the majority of cane sugar estates are located in tropical or semi-tropical climates, due consideration should be given to ascertaining that the oil used for the



Courtesy of Fulton Iron Works Company

Fig. 3—End view of a Fulton double crusher.

above mentioned bearings has adequate viscosity to maintain a suitable film of lubricant under the prevailing temperatures, which may often run around 100 degrees Fahr. In such service a summer grade of car oil will meet the operating conditions.

THE CANE HARVESTER

An interesting development during the past few years has been the perfection of a device for the mechanical harvesting of sugar cane. A feature of this machine is its ability to load the cane and separate the tops and trash after cutting and gathering, the resultant cane being delivered almost waste-free, fresh and ready for grinding at the mill. Other distinctive advantages set forth by the manufacturers are its great labor saving ability, and the extent to which it is capable of cutting canes at any desired point above or at the surface of the ground where the greatest density of juice exists. This level ground cutting is of great advantage and is said to increase the yield of succeeding crops.

From a labor-saving point of view mechanical harvesting requires distinct consideration. The world's sugar cane crop per year is in the

neighborhood of 150 million tons. Obviously the man-power required for the hand-cutting and handling of such a huge amount of cane must be enormous. The harvester is estimated as being capable of doing the work of approximately 200 men in one day of ten hours. Great

carried to the top by means of internal horizontal steps, to fall through a strong draft of air (developed by the suction fan at the rear of the drum), which effectively removes the lighter trash and tops from the drum. This air draft must be carefully regulated in order not to

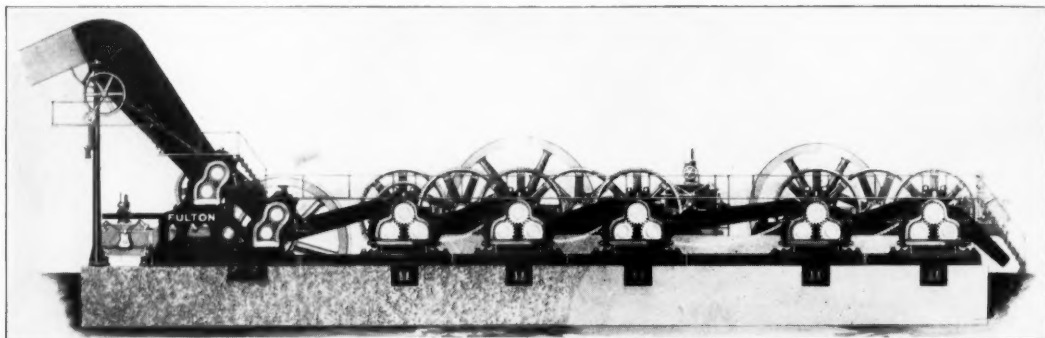


Fig. 4—Side view of a Fulton four-roller double crusher. Note relative location of gear drives and other operating parts.

Courtesy of Fulton Iron Works Company

economy is effected in transporting harvested cane from field to mill. It might seem that the use of such a labor-saving device would create a serious condition of unemployment. When one considers the necessity of experienced labor for proper hand cutting, however, and the type of labor prevalent in most sugar-growing localities, along with the wide variety of other work to which such labor could be directed, it is evident that mechanical harvesting will probably become as economic a necessity as this same operation is in the wheat and corn growing centers of the world.

Construction and Operating Details

The mechanical harvester performs its functions of cutting, cleaning, topping and loading the cane by virtue of an assembly of ground knives, feeding elevators, a chopping mechanism and a rotating separating drum equipped with a suction fan at the rear end. The above mechanisms which may be termed the chassis are assembled on a caterpillar tractor element, power being derived from a Diesel or gasoline engine. A smaller engine is installed for operation of the suction fan at a set speed.

In service the harvester is driven into the cane field pushing over the standing cane by means of its fender. The ground knives rotate inwardly, cutting the cane as the machine advances. A double set of elevators and gathering fingers assemble the cut cane and any adjacent trash, feeding this into the chopper, which cuts the entire mass into short lengths of about six inches.

The drum to which the harvested material is then delivered is virtually a separating device. As it rotates the cane and trash are

remove any of the cleaned cane, hence the necessity for the independent driving engine.

As the cleaned cane falls to the bottom of the drum it is directed to the center section which is fixed. There is a delivery aperture in this latter. Through this the cane falls through an inrush of air for a final cleaning on to the loading elevator, being capable of discharge on either side of the machine. Delivery is thereby made to some form of transportation medium for removal to the mill.

Harvester Lubrication

Harvester lubrication can be accomplished with three products, i.e., a motor oil of suitable grade for internal combustion engine lubrication, a gear lubricant of approximately 100-200 seconds Saybolt viscosity at 210 degrees Fahr., for the reduction gear elements, and a light to medium cup grease, for tractor bearings and other external bearings provided with means for grease lubrication.

There should be no difficulty in effectively lubricating the cane harvester, provided the above mentioned products are properly applied. In the case of engine lubrication, the requirements will be very much the same as those of the average tractor. Oil should be chosen for such service, in accordance with authorized lubrication charts, as issued by reputable manufacturers of lubricants, in conjunction with engine builders. Frequency of oil change in such engines is generally stated by the manufacturers.

For all parts requiring grease, it is important to remember that regular application will be necessary, especially on bearings where there may be possibility of more or less leakage during operation.

MAKING THE CANE SUGAR

The first step in sugar making is to extract the juice from the cane. For this purpose the



Fig. 5—Side view of a high type crusher, showing engines for the cane carrier drive and relative size of gearing.

canes are placed on carriers operated by machinery and carried to the great crushers or rollers of the mill, designed to squeeze out practically every drop of juice. The juice extracted by each set of rollers passes through copper strainers and is conducted through channels and pipes into one large collecting tank. Another carrier takes away the crushed residue of the canes, called megass or bagasse, which furnishes a large portion of the fuel used in sugar mills.

The cane juice is pumped from the collecting tank into the measuring tank and mixed with a certain quantity of lime for neutralizing acidity and for clarification purposes, after which it is pumped through steam heated vessels and raised to boiling point or higher. It is then pumped into other tanks, where it is allowed to settle for a short time, so that the impurities will sink to the bottom; when this is done the clear juice is conducted to a series of evaporators and vacuum pans there to be concentrated until it attains the consistency of a thick syrup.

Concentration of the cane juice is developed at a low temperature. In the "Triple Effect" the process is carried on in a series of large cells so arranged that the vapors arising from the liquor boiling in the first pan, serves to heat and boil the contents of the second pan. The third pan of the series working under a maximum vacuum of 25 to 27 inches in like manner utilizes the vapors from the second pan to heat and evaporate the liquor transferred into it. The three pans as described are called the triple effect. The syrup formed is then drawn into other vacuum pans and evaporated until crystals develop.

While the crystals are forming, constant tests are made of the boiling syrup by an employee called a "Pan Boiler," whose position is most important, in noting the gradual growth of the crystals.

When the crystals are sufficiently formed, the contents of the pan are discharged into a tank below; the substance at this stage being known as "massecuite"; it consists of crystals mixed up with a syrupy residue called molasses. The compound is a sticky, dark-colored mass which does not bear the slightest resemblance to golden sugar-crystals, yet in a few seconds, by a simple operation, it is transformed into a familiar aspect. All that remains to be done is to separate the crystals from the molasses, and for this purpose the "massecuite" is discharged into centrifugals.

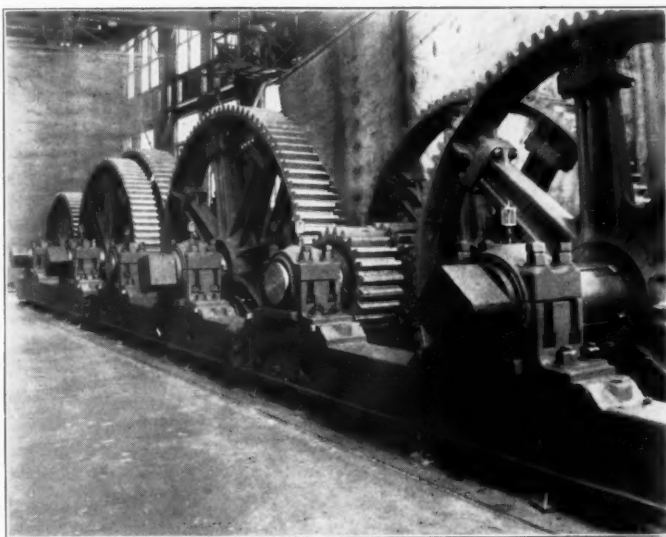
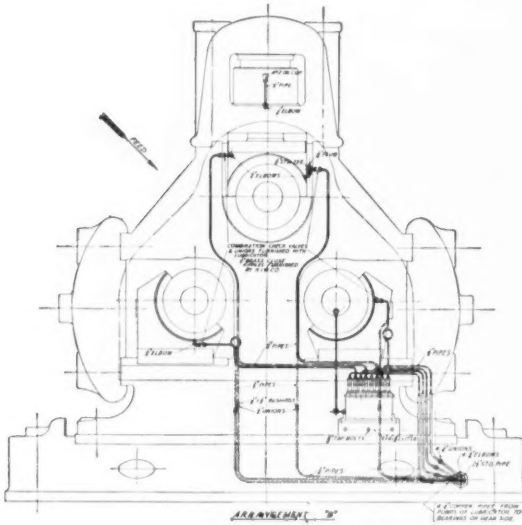


Fig. 6—An assembly of sugar mill gears with provision for individual lubrication of bearings.

CANE SUGAR MILL MACHINERY

The variety of machinery required in the cane sugar industry, the enormous size and weight of certain of the parts, and the different

speeds at which the machines must operate, is of distinct interest in studying the prevailing lubricating requirements. Consider for example an average size mill of 11 rolls. This means that there are three sets of rolls comprising in turn three rollers each, with two rolls for use as



Courtesy of Honolulu Iron Works Company

Fig. 7—Elevation of a set of mill bearings, equipped for force feed lubrication. Note points of application of oil to the bearings.

crushers or breakers of the cane as it comes from the carriers. All the sets of rolls are arranged in tandem; in some mills, however, instead of employing two rolls as preliminary crushers, two sets of revolving knives are used to cut the canes up into small pieces before it is passed on to the mill rolls; still others use large machines called shredders.

Power Equipment

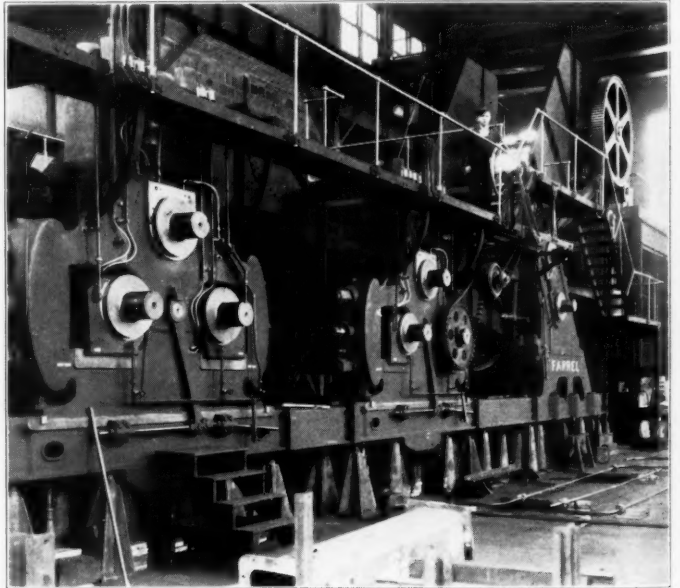
The mill rolls, crushers and cane carriers are steam driven, the engines being of unusually large size. Many have cylinders 36 inches in diameter, with a 60-inch stroke, working at about 100 pounds steam pressure per square inch, and from 45 to 70 revolutions per minute. Power is transmitted through a "spur" wheel or main gear of about 9 feet in diameter, having a face approximately 11 inches wide with teeth about $2\frac{1}{2}$ " thick. This main gear wheel weighs from 4 to 8 tons. It is the medium through which power is transmitted to the mill rolls, crushers and cane carriers.

The fly wheel of the main engine ranges from 12 to 20 feet in diameter, in some cases weighing as high as 26 tons.

The steam engine is not the only means of drive, however, for the electric motor has been proved adaptable, especially in Cuba where some of the largest sugar mills in the world are located. And yet, by reason of the type of refuse fuel so extensively available, steam is highly suitable and even where it may not be used directly in the main drive, other steam units will be found in the form of turbines, vacuum pumps, and auxiliary drives for the evaporators, centrifugals, and fans. The centrifugals range in number from 4 to 20 or more, according to the capacity of the mill. They range from 30 to 54 inches in diameter, and have an average speed of 1200 revolutions per minute. Some require oil, some grease for lubrication, according to design of the bearing elements and the means provided for application.

Roll Construction

The average mill rolls and crushers will range in size from about 20 inches in diameter by 36 inches long, to 40 inches in diameter by 88 inches long, with journals from 12 to 22 inches in diameter. These latter are probably the most difficult elements to lubricate in the cane sugar industry, on account of the immense pressure required to extract the juice from the cane. In



Courtesy of Farrel-Birmingham Company, Inc.

Fig. 8—Showing an 8 roll cane sugar mill, equipped for automatic lubrication of bearings.

fact, by use of hydraulic pressure applied to the top rolls from 200 to 650 tons pressure can be developed, according to the size of the mill. Such intense loads on the roll neck bearings will cause serious trouble, due to over-heating, if lubrication is not given most careful consider-

ation. If allowed to continue, a shut-down for repairs may be necessary, with resultant loss in production.

Lubrication

For the lubrication of the heavy mill roll, crusher and gear bearings, on account of the high pressures, a heavy bodied lubricant is necessary. The average engine or machine oil does not have sufficient viscosity to keep the surfaces apart, on account of the comparatively slow speed and heavy pressures. A lubricant of 150 to 200 seconds Saybolt viscosity at 210 degrees Fahr., will normally meet the requirements and a straight petroleum product seems to give better results than a grease or compound. This type of lubricant also has the advantage of adhering tenaciously to the bearings and of not being worked out by the variations of pressure to which the latter are subjected. It also has another important advantage in that it is comparatively cheap, which on account of the size and number of large bearings, is not an inconsiderable factor. A similar type of lubricant, of higher viscosity however, ranging in the neighborhood of about 1000 seconds at 210 degrees Fahr., is best suited to the gears. This product should be very adhesive to metal and of such a consistency that it will not run, drip or crumble from the teeth; yet, it must be sufficiently plastic to furnish complete lubrication.

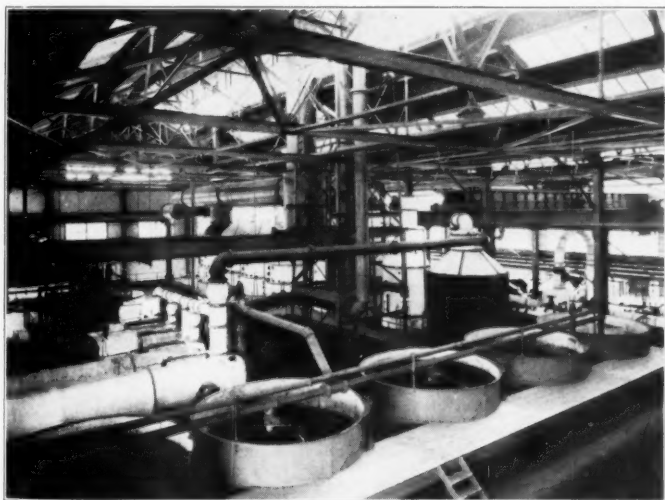
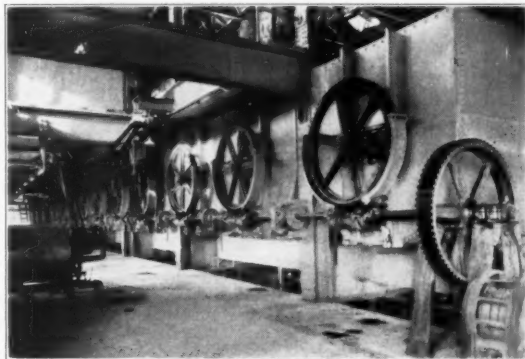


Fig. 9—Interior of a sugar mill clarification house, showing drier tanks, juice heaters, pre-evaporators, etc.

For gears and chains operating under comparatively exposed conditions, a heavy bodied gear lubricant has been found advisable. Chain lubrication should be given careful consideration from the viewpoint of the type of chain link involved, and the extent to which the

chains may be housed. Under exposed conditions the above mentioned gear lubricant will prove entirely satisfactory.

Where the so-called silent type of chain is used, however, in an oil tight housing, it will be better to use a more fluid product. Under such



Courtesy of Honolulu Iron Works Company
Fig. 10—Showing a battery of sugar mill crystalizers. Note method of guarding certain of the gears.

conditions an oil having an approximate viscosity of 100 seconds Saybolt at 210 degrees Fahr., should serve the purpose.

Gear lubrication will require particular consideration in view of the general size which prevails and the fact that in many cases the gears operate exposed. It is, therefore, highly essential to select a lubricant which will adhere tenaciously to the gear teeth and will resist the throwing off effects of centrifugal force, should gearing be operated at comparatively high speeds. Normally, however, slow speeds will prevail.

Function of the Centrifugal

The centrifugal is probably the key machine in the refinement of both cane and beet sugar. By its action separation of the actual sugar crystals from the molasses or syrup is brought about. The action of the centrifugal is very much the same as that of a laundry dryer or extractor. In service the mixture of syrup plus sugar crystals known as "massecuite" is pumped into the bowl or revolving element of the centrifugal. Rotation of this latter at speeds in the neighborhood of 1200 revolutions per minute forces the molasses

or syrup through the minute holes in the wall of the bowl, the sugar crystals being retained in the latter in a comparatively dry state if rotation has been carried on for a sufficient period of time. Normally this can be accomplished in about two minutes.

In a golden shower, the crystals are then tumbled out into a conveyor, which runs them up to the storage bins, ready for packing and shipping. The sugar leaves the storage bins via a chute to the ground floor; a weighing machine stands beneath its outlet which can be

Oil lubrication is most customarily provided for, the modern centrifugal being provided with an oil reservoir at the base of the head. By use of suitable scoops attached to the sleeve as the oil in the reservoir is extended up the walls of the base during rotation, these scoops

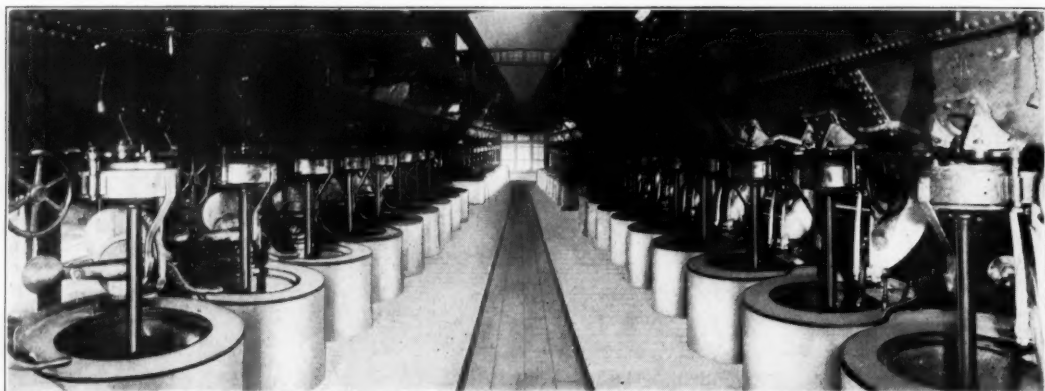


Fig. 11—Interior view of a series of belt driven centrifugals.

Courtesy of American Tool and Machine Company

opened or shut as desired by a slide. Empty bags take their turn on the weighing machine, and as each one gets its fill of 250 pounds, or 8 bags to a ton of 2,000 pounds, it is removed and securely fastened. In Cuba a bag of sugar weighs 320 pounds, or 7 bags to the long ton of 2240 pounds.

The color of sugar is determined by its degree of purity, pure sugar being white, or strictly speaking, colorless. The sugars made at cane and beet mills are, as a rule, gray, brown, or some shade of yellow from pale lemon to bright gold. Those of yellow hue have been sufficiently clarified to be sold for household use; the grays and most of the browns go on to a refinery, where they are melted and subjected to a more rigorous purification. Bone char plays a very active part in the bleaching and final refining of sugar.

Lubrication

Centrifugals may be either belt or motor driven. The tendency in modern design is to adopt the motor drive, by reason of the more positive control available. In operation, massecuite is charged into the centrifugal via a central opening at the top, while the bowl is in motion. The wire gauze liner of the bowl effectively retains the sugar crystals, the mother-liquor being thrown off virtually immediately.

By virtue of the speeds involved, and the necessity for maintenance of even balance of the rotating element, lubrication of the head bearings is of distinct importance. These may be either of the plain sleeve type design, or they may involve anti-friction bearings.

carry it up to the top of the head, via piping or a hole drilled in the base casting, to be subsequently led to the spindle bearing. Through the clearance of this latter it is returned to the reservoir for recirculation.

Experience has indicated that a medium viscosity straight mineral oil will serve the purpose under normal operations, the Saybolt viscosity ranging from 300 to 500 seconds at 100 degrees Fahr. The higher viscosity should be considered where unusually large units are involved. On the other hand, one must remember that the higher the viscosity, the less fluid will be the oil and consequently the internal friction may be greater. In some installations, this would lead to increased operating temperatures.

BEET SUGAR MANUFACTURE

In contrast with the cane sugar industry, where the raw product is subjected to roll pressure for extraction of the juices, in the extraction of beet juice water diffusion is employed.

The first step involves a thorough washing and weighing, following which the beets are put through slicing machinery. Here they are cut into slices, or shreds, known as cossettes, by knives revolving in either a horizontal or vertical plane, according to the design of the slicing machine. From here the sliced raw product is carried to cells or vessels of from two and one-half to seven tons capacity, where they are subjected to water circulation.

During this diffusion process the beet-root juice escapes from the plant cells to mix with the water, while the water begins to penetrate

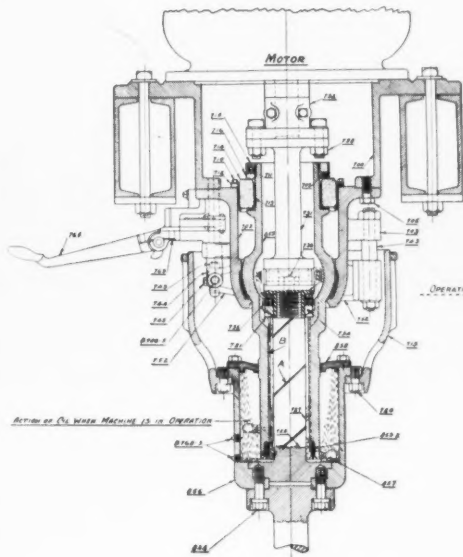
the cells to mix with their juice. This action goes on until the liquid within the beet-shreds and that in which they are immersed are of equal density, by which time what was originally water has become syrup. This syrup is conducted to a second vessel containing cos-

settes. This involves carbonation whereby lime slacked by a dilute sugar solution or saccharate of lime is added, and the mixture is then treated with carbon dioxide gas until most of the lime has been precipitated as calcium carbonate.

After carbonation has been completed to the desired degree, the mixture is again heated, either in the tanks or by being pumped through heaters, following which it is passed to the first filter presses, where the precipitated calcium carbonate and any other impurities contained therein (known as the first lime cake) are removed.

This purified juice from the first filtering process is known as first press juice. From the above presses it is subjected to a second carbonation treatment, whereby most of the remaining lime is precipitated by further contact with carbon dioxide gas.

From the second carbonation the juice is led to a second series of filter presses, where the precipitated calcium carbonate is removed as second lime cake the filtrate being known as second press juice. The next process involves saturation, wherein the juice is treated with sulfur dioxide gas. After this treatment it is again filtered, this time through what are known as thin juice filters. The resultant filtrate, which is called the third press juice, is then passed to evaporators, where it is concentrated to a syrup containing about 50 per cent. sugar. The juice leaving the evaporators is known as evaporator thick juice. The next step involves what is known as blowing-up, wherein this juice is mixed with melted sugar and then treated with sulfur dioxide gas. After subsequent filtering through so-called thick juice filters the resultant syrup is termed blow-up thick juice. Further



Courtesy of American Tool and Machine Company

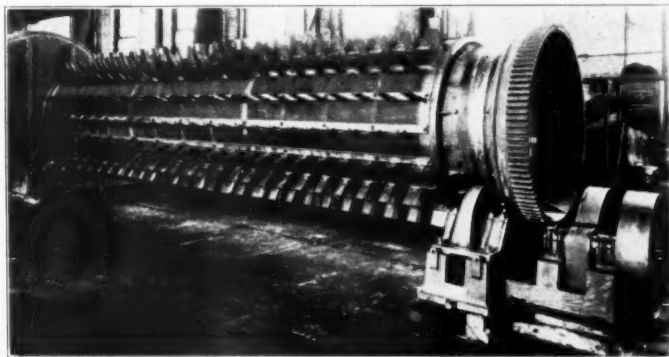
Fig. 12—General assembly of oil flooded bearing, as used in an electric driven centrifugal. Oil is carried in reservoir (856), following an upward path during rotation via spiral grooves—A, and vertical grooves—B.

settes, and the same natural mixing again takes place, the original syrup being strengthened with a further supply of sugar juice; this process is repeated until diffusion practically ceases, or until the immersion liquid has become saturated with beet juice. The diffusion or resultant syrup at this stage corresponds with cane sugar juice after extraction by crushing.

Ten to fourteen diffusion cells constitute a battery, being connected in such a manner that the water passes from one cell to another, beginning at the cell that contains the most nearly exhausted cossettes, being finally drawn off as diffusion or raw juice from the cell in which the new cossettes are added. The exhausted cossettes, when free from all but a small percentage of sugar, are known as pulp, and are used as a cattle feed.

Purification

Following the process of extraction, the juices are subjected to purification. The diffusion or raw juice is led through heaters, from whence it is subjected to milk of lime treatment.



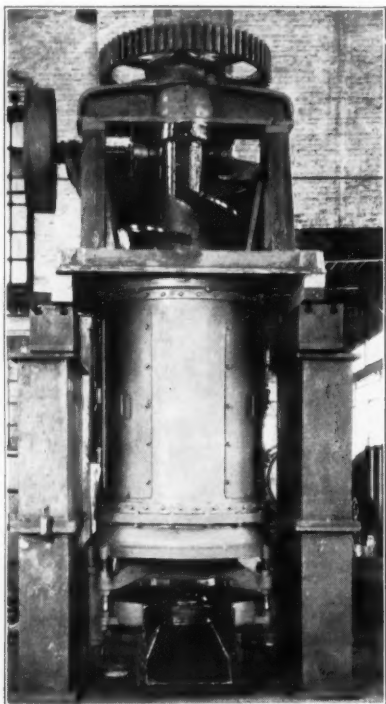
Courtesy of The Kilby Manufacturing Company

Fig. 13—Showing the revolving drum of a waste gas pulp drier. Roll and trunion bearings will be noted in the foreground.

concentration of this juice is brought about in the white vacuum pan, where it is concentrated to such a point that the sugar content crystallizes out. The whole mass of crystals and liquid surrounding them is called white filmas.

Centrifugal Treatment

This product is placed in centrifugals, where the crystals are retained on a screen, the syrup passing through as a product known as high green. Since some of the syrup remains on the



Courtesy of The Kilby Manufacturing Company
Fig. 14—Showing a Kilby high capacity pulp press.

crystals, it is necessary to wash them with a spray of hot water. The washed crystals are then dried by air in granulators and sacked as granulated sugar.

The wash liquor in turn goes into the next white vacuum pan, the high green being drawn into the remelt or raw pan and concentrated to such a point that crystallization takes place. This mass of sugar crystals and the syrup surrounding them is known as remelt filmas.

The crystals are then separated from the syrup by centrifugal force in the same manner as was done with the white filmas. The resultant syrup spun off is known as low green. The washed crystals are called remelt sugar and the syrup obtained during the washing is designated as low wash.

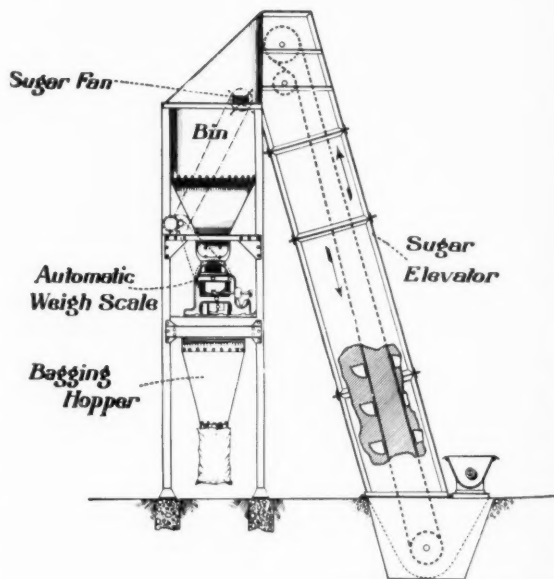
This remelt sugar is then melted up and added to the thick juice at the blow-ups; the low wash goes back to the next remelt, and the low green is sent out of the factory as molasses, which is either used for cattle feed or subjected to a further extraction process.

Beet sugar manufacturers are continually conducting investigations for the improvement of this process and as a consequence it is being changed from time to time.

Lubrication

A distinctive problem prevails in the lubrication of beet sugar machinery, by reason of the natural acids which are formed during the process of extraction, as well as the various other acids used to expedite this extraction. As a consequence, the bearings, gears, and chains of the machinery involved must be carefully protected by lubrication. Sleeve type, babbitted bearings are extensively used on such machinery as beet slicers, centrifugal pumps, melters and certain types of centrifugals; use of ball bearings is practicable, however, on the spindles of the latter machines.

Where plain bearings are involved, either grease or oil lubrication is practicable, according to bearing design. Ring oilers, of course, require oil. The use of grease cups is quite prevalent, however, on the step assembly of centrifugals. Beet slicers are quite generally provided with plain Babbitted bearings. When



Courtesy of Link-Belt Company
Fig. 15—Diagrammatic view of a Link-Belt sugar elevator and bin.

fitted with pin-type lubricators, a light bodied grease has proved very satisfactory. The slicing machine is belted to an electric motor, on which a straight mineral oil of around 180 seconds Saybolt viscosity should be used in the ring oiled bearings. This same oil should be used on the ring oiled bearings of electric driven centrifugal pumps.

The screws of the battery cells in turn can be lubricated with the same grease as used on the slicer bearings. The carbon dioxide pump, which is often of the root blower type, is generally direct-connected to a vertical engine. Trunnion bearings of the blower have been very successfully lubricated by a medium heavy viscosity steam cylinder oil. The driving engine to which the pump is connected requires two types of lubrication; viz.: crank case, wherein provisions for splash oiling have proved the advisability of using a comparatively light oil of a high degree of demulsibility, having a viscosity of around 180 seconds at 100 degrees Fahr., and a compounded steam cylinder oil, as mentioned for trunnion bearings, for steam cylinders.

Filter press screws, incidentally, can be adequately lubricated by this same grade of cylinder oil, compound being of advantage as an emulsifying agent in the presence of moisture. The sulfur stove, in turn, as an adjunct in development of sulfur dioxide, is also of interest. Essentially, it is nothing more than a round cylinder. The sulfur is delivered preparatory to ignition by an automatic feeder to the inside of the cylinder. This feeder is motor driven through a speed reducer and a chain drive on the cylinder. The 180 second viscosity mentioned above can be used for lubrication of the motor. A heavy bodied straight mineral gear oil is necessary, however, for the speed reducer. This same product can be used for chain lubrication, although certain installations require a somewhat heavier and more adhesive lubricant, in the interest of chain link protection.

For other bearings such as those which serve to support the sulfur stove, a medium viscosity machine oil will serve the purpose.

Melters require two types of lubrication, as they involve plain bearings and bevel gears. For the former a medium consistency cup grease should be used in compression cups on the drive bearings. The bevel gears, however, require a heavy gear lubricant of approximately 1000 seconds Saybolt at 210 degrees Fahr., to insure adequate tooth protection under the prevailing operating temperatures.

Centrifugals

These elements are among the most important machines in the beet sugar industry, just as they are in the cane sugar refinery. In the beet refinery their manner of installation requires particular consideration of lubrication. In many plants from 15 to 20 centrifugals are belted to one common line shaft, driven by a single electric motor. Ring oiled motor and line shaft bearings require a light viscosity oil as described in connection with the carbon dioxide pump. Other lubricated elements on

the beet sugar centrifugal involve step and spindle bearings. These latter may be of either plain or ball bearing type. Plain bearings are generally designed for oil lubrication, using a medium 300 viscosity machine oil. Ball bearing spindles, however, may require a somewhat higher viscosity lubricant. In view of the operating conditions it should be a highly refined product, capable of maintaining continued protection and lubrication of the bearing elements without deterioration, gumming or separation.

Step bearings of the average centrifugal carry considerable load. For this reason they require a heavy, load-resisting grease, capable of withstanding pressure, and able to follow the moving elements without development of undue internal friction. Use of a heavy bodied oil in the manufacture of such a grease will develop these characteristics if the product is properly compounded.

DRYER OPERATIONS

The purpose of the dryer is to remove any final traces of moisture which may have remained after the sugar has left the centrifugal and been lightly sprayed with water in order to improve the color.

The dryer involves an inclined cylinder much like a cement kiln, capable of rotation, motion being imparted by gear drives. The weight of the dryer is normally carried on trunnions, equipped with suitable rolls.

Heat is developed within the dryer by means of steam or hot air. Where steam is used the air is heated by steam coils located at the lower end of the dryer, or an interior steam cylinder, also capable of rotation, is located along the axis of the dryer cylinder. Drying is brought about by hot air circulation through the mass of sugar crystals. This is expedited by subjecting these latter to a tumbling action as the sugar passes through the dryer from the high to the low end, lifting shelves being attached lengthwise to the internal wall of the dryer, for the purpose of mixing. During this agitation, which occurs once each revolution, the currents of air flowing counter to the flow of sugar, are able to circulate freely throughout the entire mass of the sugar until it is rendered perfectly dry, when it is discharged from the lower end.

Direct heat dryers using waste furnace gases are used in the beet sugar industry for drying pulp, intimate mixture being brought about by paddles.

Lubricating Requirements

As dryers revolve only a few revolutions per minute, speed does not create any unusual lubricating problems. Bearing and gear tooth

pressures, however, are comparatively high, for heavy loads must be carried. Furthermore, there is always possibility of difficulty, due to the heat which is radiated from the dryer. The trunnion bearing may frequently run hot. For this reason, grease lubrication has been found to be very satisfactory.

It is also practicable, however, to lubricate such parts with heavy oil, dependent upon the means for application, especially where dirt can be kept out of the bearings.

Regardless of the type of lubricant, however, it is important to remember that whenever the maintenance of high temperatures is essential, the radiated heat may thin down certain lubricants to such an extent as to reduce their lubricating ability seriously.

The Driving Mechanism

The general matter of gear lubrication must be given very careful attention in connection with the driving mechanism. This is especially true where operators have been accustomed to believe that black oils are satisfactory lubricants. Frequently they might be—for average temperature service—but they will be quite unsuited for higher temperatures.

It must also be borne in mind that dust and grit aid high temperatures in drying up a lubricant. As a result, only a specially prepared product of pronounced adhesiveness, having a high liquefying point and considerable body, will be capable of preventing metallic contact and providing efficient lubrication.

Trunnion Bearing Lubrication

Bearings of the trunnion type present one of the most difficult lubricating problems in any type of kiln or dryer operation. This is due to the fact that:

1. Comparatively heavy loads must be carried.
2. The trunnions often become heated, due to their proximity to the shell, and
3. Considerable dust and grit may find their way between the bearing surfaces.

The essential remedy for all of these troubles is a grease or oil possessing considerable body and a high liquefying point. On the other hand, it is practicable to effect a certain amount of temperature reduction by making provision for cooling water circulation.

Trunnion bearings are generally of large size. Furthermore, in view of the fact that all the thrust is downward, certain types of bearings are very often lined on the bottom half only; this lining can be readily replaced when worn. Inasmuch as the caps of such bearings may

carry no lining, they merely serve as dust shields and receptacles for the lubricant.

It is interesting to note that considerable study has been given to the development of means for automatic lubrication of trunnion bearings, these latter being normally of the two-part type, with a cap lined in very much the same manner as a standard type of plain bearing. Oil is carried in a suitable reservoir below the bearing, being distributed by a dipper device, which is rotated by the shaft.

Normal construction is to provide two of such dippers which at every rotation automatically fill themselves with oil to empty same along the top of the shaft. From this point oil is distributed throughout the entire clearance space. These bearings are normally water-cooled; as a result, it is not essential to resort to an extremely heavy-bodied lubricant.

By reason of their construction, and the ample oil supply available, they insure effective lubrication to a high degree. There is but little opportunity for entry of abrasive foreign matter, and the fact that the bearings are flooded with oil insures that any dust or dirt which may be present will be flushed out from the clearance space by the oil.

The roller bearing has also been adapted to trunnion design, with evidence of being quite as advantageous as the self-oiling plain bearing. As a general rule, however, the roller bearing will not have as ample a lubricant reservoir. Furthermore, there may be provision for oil or grease lubrication, according to the design and the provisions made for application by the builders.

Trunnion bearings can also be effectively lubricated by wick feed oilers. These latter, by virtue of the fact that they assure more positive lubrication, will increase the dependability of operation through reduction of bearing wear. This will, of course, lead to reduced maintenance and repair costs.

Wick oilers are particularly adaptable to existing installations, due to their low first cost and the ease with which they can be substituted for more crude means of lubrication.

More attention, however, may be required with such a means of lubrication, for the cups must be refilled with a few ounces of oil about twice daily, whereas with grease lubrication certain cups or boxes will carry sufficient lubricant for a week or more.

Regular examination of such oilers is advisable in order to check any possibility of oil carbonization at the bend of the wick, for if allowed to continue it may impair the flow of oil through the wick to the bearing. It can be corrected by rubbing the wick between the fingers.